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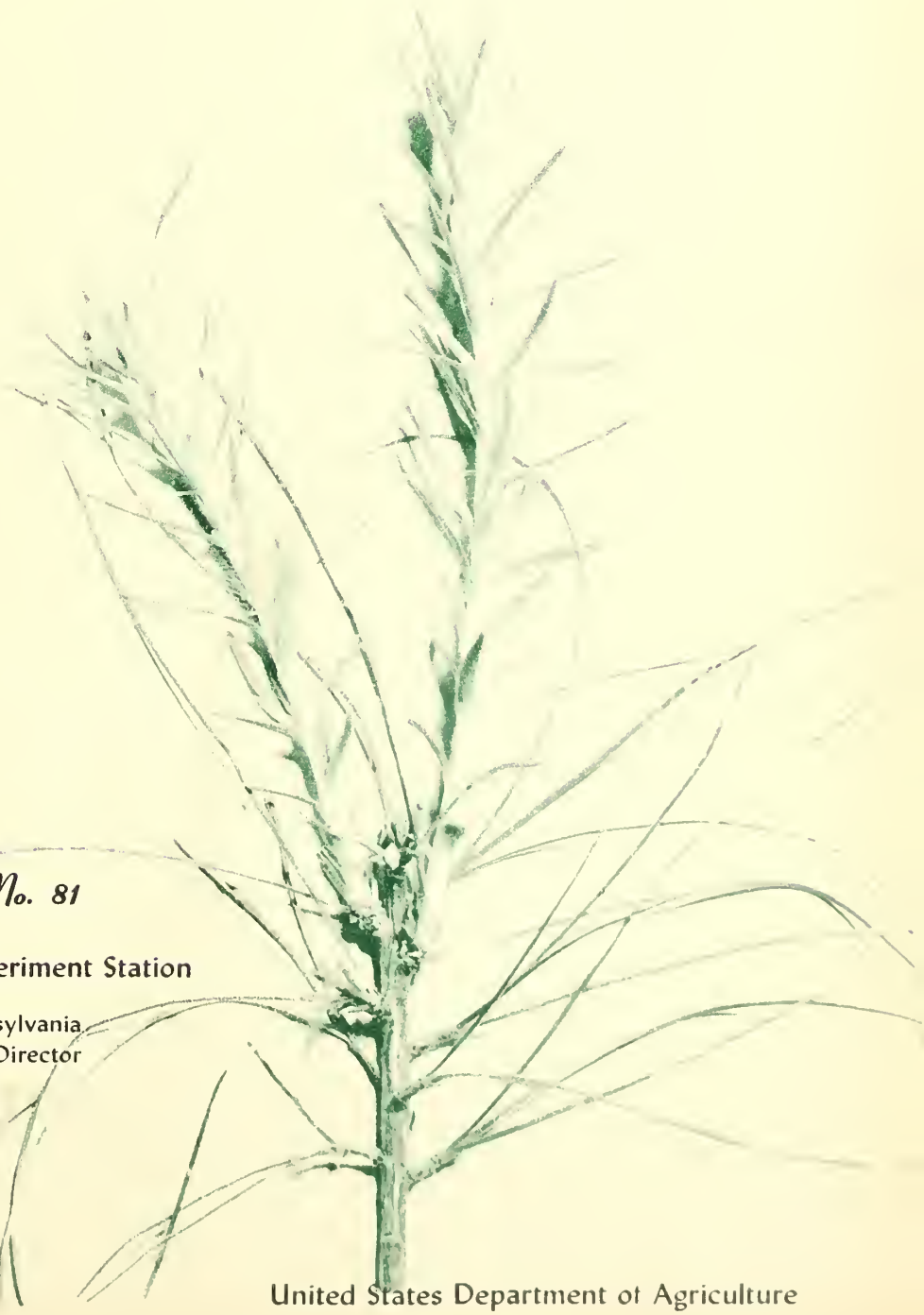

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Buds Enable Pitch And Shortleaf Pines To Recover From Injury

by

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PITCH AND SHORTLEAF PINES often survive severe damage by fires, cutting, rabbits, or deer. Deer may take all but 2 inches of the 6- to 8-inch shoots of seedlings, and still these seedlings may live and develop new shoots. Fires may kill all the foliage and terminal shoots on sapling or pole-size stems, but still these trees may green up and develop new leaders. Many of the pines in southern New Jersey today have two or more crooks where past fires killed 1 to 3 feet of their leaders.

How do these pines recover from such drastic injuries, or even less damaging ones?

There are two sources for the new shoots. One is the development of buds in the needle fascicles below the point of injury, as on pines sheared for Christmas trees. As Dr. E. L. Stone of Cornell University pointed out in a letter to the authors, these needle fascicles are short shoots; and potentially each fascicle or fascicle site is a source

[1]Stationed at the Lebanon Experimental Forest, New Lisbon, N. J., which is maintained by the Northeastern Forest Experiment Station in cooperation with the New Jersey Department of Conservation and Economic Development, Bureau of Forestry, Parks, and Historic Sites.

of shoot meristem. That fact, though not new, seems to be overlooked by some foresters, who call these buds "adventitious."

More commonly, however, the recovery is made through dormant buds. [2] Some of the earlier authors--such as Harlow and Harrar (1) on shortleaf pine and Illick and Aughanbaugh (2) on pitch pine--called these buds adventitious, but the Stones (5, 6) showed that they are actually dormant or latent buds.

Though the Stones described the origin of dormant buds, they did not mention how long the buds are present in pitch and shortleaf pines, nor how the recovery of these species varies with age. Differences in the ability of these two species to recover from damage may account for differences in their relative abundance, in the growth and form of their sprouts, and thus for much of the variability in stand composition and growth in the Pine Region of southern New Jersey.

NEEDLE-FASCICLE BUDS

Probably all species of pine can recover from animal damage or other injuries (such as shearing for Christmas trees) by developing buds in the needle fascicles below the point of injury (fig. 1).

Both to check the development of needle-fascicle buds and shoots in pitch and shortleaf pines, and to determine whether such buds can develop on growth older than the current year, four pitch pines and four shortleaf pines 3 to 6 feet tall were sheared on August 17, 1953. On four trees (two of each species) only part of the 1953 growth was removed. On the other four all of the 1953 growth and some of the 1952 growth was removed from the leaders and uppermost laterals. All laterals were treated that if untreated might have turned up and become the leader, or through an auxin effect might perhaps have limited the formation of new buds on the terminals.

In the spring of 1954, needle-fascicle buds and shoots developed on all treated trees, on practically all shoots sheared. So the needle fascicles of pitch and shortleaf pines do remain a source of shoot meristem for at least 13 months.

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[2] Underlined numbers in parentheses refer to Literature Cited, page 13.

Figure 1.--*Needle-fascicle shoots. The stem was clipped and two new shoots developed from needle fascicles just below the cut. Note that most of the new sprout growth has primary needles—those borne singly—although needle fascicles are developing in the axils of the upper primary needles. Such a regression in type of needles borne is characteristic of sprouts from either needle fascicle or dormant bud.*

The first-year growth of the needle-fascicle shoots was good on all stems where only part of the 1953 growth had been removed. Where all of that and some of the 1952 growth had been removed, the new shoots were only about half as long.

However, needle-fascicle buds are relatively unimportant in the recovery of pitch and shortleaf pine from injury. Usually they develop only when a little of the new growth is removed from the leader and laterals by deer, rabbits, or insects. Most often either an undamaged lateral turns up and becomes the leader, or the damage is extensive

enough so that in these multinodal species dormant buds are present just below the point of injury.

DORMANT BUDS

Pitch and shortleaf, like the other pines, form buds in the axils of the primary needles just above the cotyledons, and more buds at each node or end of a stage of height growth. Unlike white pine, pitch and shortleaf have two or more stages of height growth in a growing season when they are young and vigorous. In white and loblolly pines the buds formed at those places apparently develop into branches or die within a few years. But in pitch and shortleaf pines these buds may persist in one form or another for many years.

The Stones (5) observed that dormant buds persisted as such in pitch pine for at least 4 years. But more commonly after 2 or 3 years they developed into minute stubby branches bearing single fascicles or small clusters of fascicles.

However, many dormant buds can be found on trees much older than 4 years, and these may arise from the subdivision of older buds. For example, in both species a stimulated bud may subdivide and form many new buds, sometimes producing a dense cluster of as many as 42 buds. If a bud is stimulated sufficiently to develop into a branch or shoot, new buds are formed at its base and along its length (at the nodes).

As the tree grows, the union between branch and bud often becomes hidden. If the branch dies, one or more of the buds that arose from it may be stimulated to develop, or all may remain dormant. Of course, many buds die, but with such production and growth of buds many living ones remain for a long time on trees of both species. These characteristics have been reported in detail by the Stones (5, 6); and we have observed the same thing.

Basal Sprouts

Dormant buds at the base, just above the cotyledons, are the source of basal sprouts in pitch and shortleaf pine (fig. 2). Thus, as long as the deer do not nip these off or uproot the seedlings, even trees 1 year old may recover from severe browsing.

Sprouting after a fire depends on the buds being protected by thick bark or by a basal crook that brings the

buds below the litter. According to Wakeley (7), this crook at the root collar develops on most of the nursery-grown shortleaf seedlings during the first year; but a crook does not develop on overcrowded, weak, or otherwise backward stock.

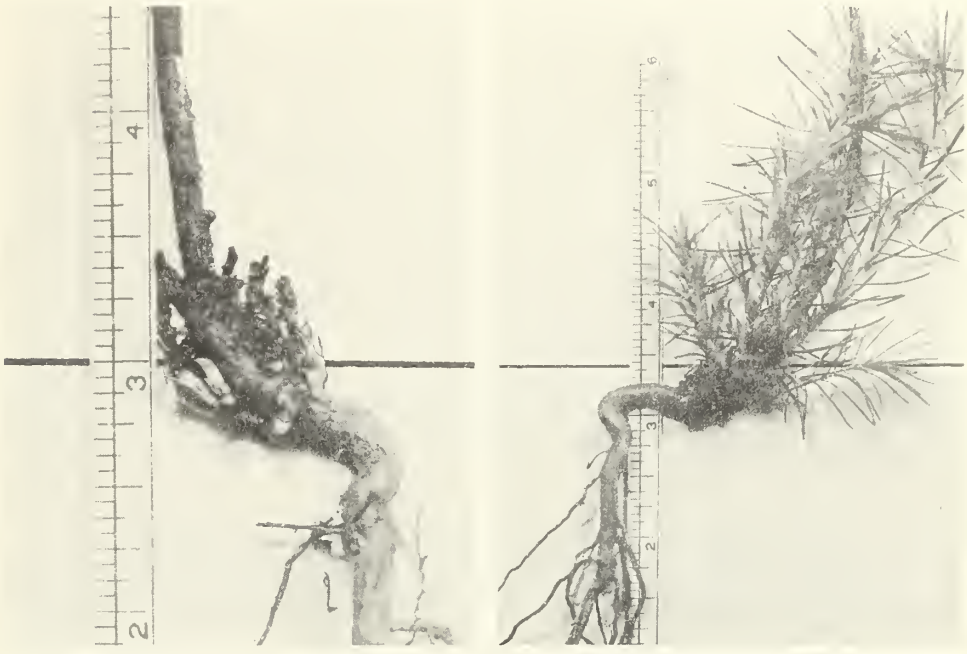

Figure 2.--*Shortleaf pine seedlings that sprouted after a fire.* Left: *seedling with dead basal branches and buds that are expanding into new shoots.* Right: *a later stage in the development of basal sprouts from dormant buds; the lower buds in the basal cluster, though still alive, did not sprout. The scale shown is in inches. The black line marks the boundary of fire-kill in stem tissue.*

In natural reproduction, only the most vigorous open-grown seedlings of pitch and shortleaf pine develop this crook during the first year; and most shade-grown stems do not have a well-developed crook until they are between 3 and 9 years old. Of 75 shade-grown shortleaf pine seedlings that were examined, 40 percent of those 4 or 5 years old had well-developed crooks, compared to 92 percent of those 6 or 7 years old. These seedlings had been receiving some side light, so they were typical of the more vigorous reproduction grown under a stand. For contrast, in a spot where pitch pine seedlings had been severely suppressed by bear

oak and had remained spindly, half of the 50 examined when 9 years old had such poorly developed crooks that they were considered susceptible to killing by fire.

Since these data indicate that shade-grown reproduction may take a few years to develop well-formed crooks, perhaps the progress of this development should be described. The following explanation is based only on general observations--we have not followed the process through in detail on marked plants.

The first apparent change from an upright position occurs when the seedlings are still very small and relatively young, usually during the first or second growing seasons. Pitch pine stems are then usually less than 4 inches long and less than 1/10 inch in diameter at the bending point; shortleaf pines are smaller than pitch pines. Possibly from their own weight, the stems bend--shortleaf pines usually at a point low in the hypocotyl section of the stem. Some pitch pines also bend at a point in the hypocotyl section of the stem, but many at a point somewhat above there. Above the bending point the stems may become almost prostrate or at least grow at an angle from an upright position.

Within a few years--often within a year for open-grown seedlings--the stems appear fairly upright although a basal crook remains. The straightening occurs not only at the tip, but below it as well. The hinge or second crook is often just above the hypocotyl in shortleaf pine seedlings, frequently further up the stem in pitch pine seedlings.

Sectioning 15 seedlings of each species indicated that variable widths of the growth rings (much wider on one side than on the other), sometimes accompanied by compression wood, may account for the observed change in form below the growing tips. This variable diameter growth seems not only to straighten the stem resulting from a growing tip that turns up, but also to accentuate the crooks. Thus the lop-sided growth in certain spots along the stem, plus straightening at the tip, results in appreciable changes in form as the stems increase in size. What started as a stem slanting from the ground may become a short horizontal section of stem along the ground, then a sharp crook, and then an upright stem.

Vigorous open-grown seedlings of natural origin usually take longer to develop such pronounced crooks than does nursery stock, and of course shade-grown reproduction may take several years to reach a comparable size and stage of development. And, particularly if shade-grown, pitch pine

seedlings have much more sweeping and variable crooks, and take longer to straighten, than do shortleaf seedlings.

On upland sites the continued growth in diameter of the seedlings of both species of course brings against or into the mineral soil the dormant buds that are slightly above the hypocotyl and on the lower side of the crook. Still further growth of the stems--to saplings or mature trees--obscures or completely hides the basal crook. More intensive observations on the crook development of marked seedlings are planned for the future.

Of course there are occasional seedlings that never develop crooks, and there are situations where basal-crook development is not important in favoring sprouting after fires. For example, in disked or bulldozed areas, soil deposits around seedlings are often enough to bury the hypocotyl and basal buds. On the poorly drained lowlands pitch pine seedlings that start in Sphagnum or on a deep humus layer cannot be expected to survive a subsequent fire that burns much deeper than the surface where the seedlings started. That has happened in recent years in summer fires during extended dry periods.

Because many shade-grown pine seedlings 3 or 4 years old on upland sites lack well-developed basal crooks, we also cannot expect that they will sprout after wildfires in New Jersey--even though Moore (4) reported that planted shortleaf pines 4 years old sprouted after a wildfire, and Mattoon (3) showed sprouts from 3-year-old shortleaf seedlings that had been killed by a fire.

The ability of pitch and shortleaf seedlings to survive light fires, such as those used in prescribe-burning upland sites, varies greatly. From observations on staked seedlings it is evident that only an occasional one of the 1-year-old seedlings survives by sprouting. Whether older seedlings sprout seems to depend more on their vigor, on the development of a basal crook, and on their diameter at the root collar than on their height or age.

In 1955, 100 shortleaf seedlings on an upland site and 98 pitch pine seedlings on a lowland site were staked, measured, and subjected to prescribed burning. All were more than 1 year old and were growing under shade, but the shortleaf seedlings were more vigorous than the pitch. About 20 stems of each species were in each of the following diameter classes at the root collar: 1/16 inch, 2/16 inch, 3/16 inch, 4/16 to 5/16 inch, and 6/16 to 8/16 inch.

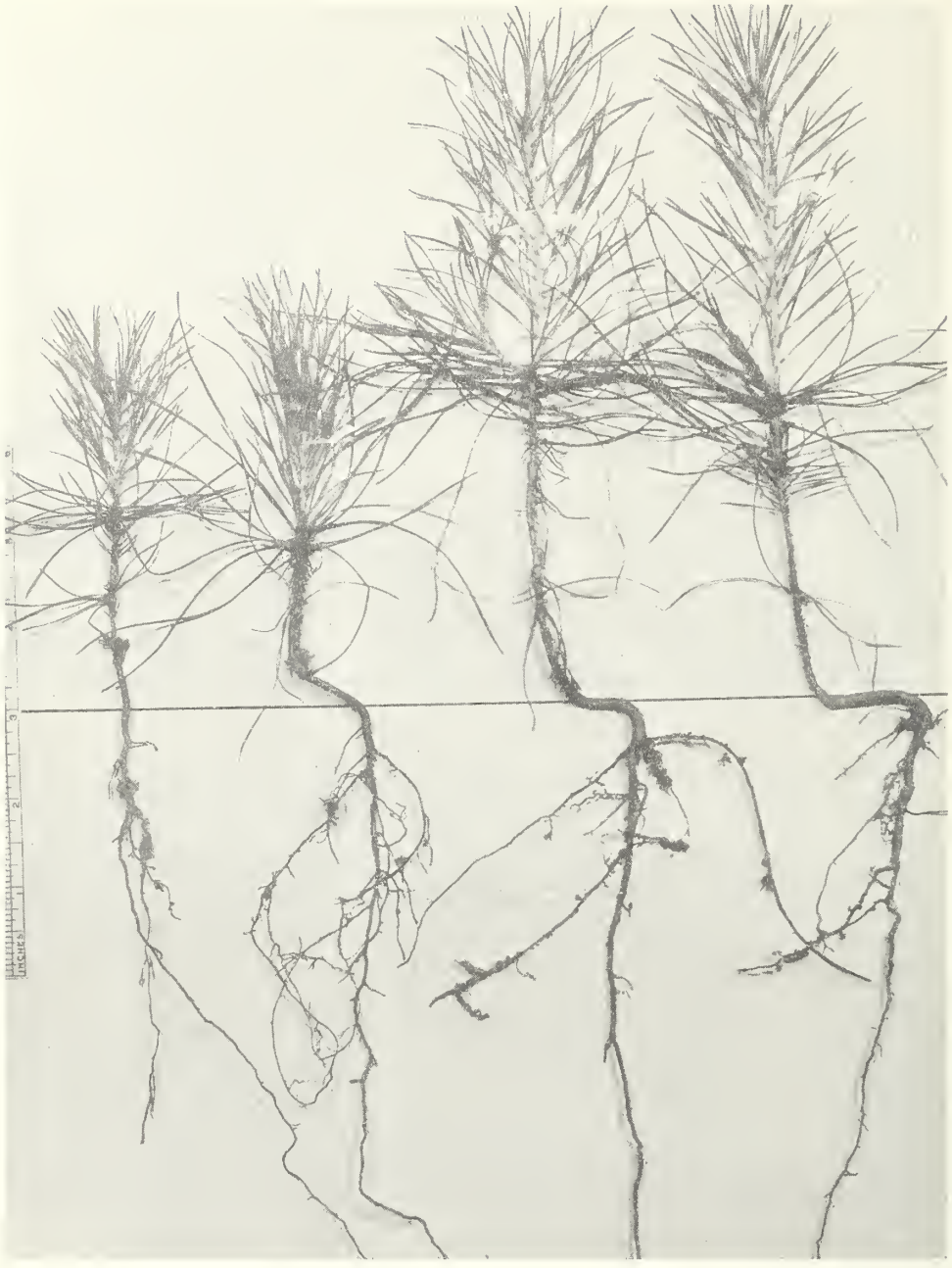

Figure 3.--*Shortleaf pine seedlings that illustrate the four classes of basal-crook development.* Left to right: *none, slight, well developed, and very well developed. Since the black line here represents ground level, only in the well developed and very well developed classes are the dormant basal buds at or below the soil surface so they could survive fires that consume most of the duff.*

By those size classes the shortleaf pines that sprouted were respectively 15, 65, 70, 80, and 100 percent of those treated. Comparable values for pitch pines were 0, 26, 42, 45, and 75 percent.

Of the treated shortleaf seedlings, 33 percent of the ones with no basal crook sprouted, 39 percent of those with a slight basal crook, 81 percent of the ones with a well-developed crook, and 93 percent of those with a very well-developed crook. (Figure 3 illustrates these classes of basal-crook development.) Among the pitch pines, only in the group with a very well-developed crook did more than 55 percent sprout.

All treated seedlings 0.1 foot tall failed to sprout. But 19 percent of the shortleaf seedlings 0.2 to 0.3 foot tall sprouted, as did 62 percent of those 0.4 to 0.5 foot tall, 74 percent of those 0.6 to 1.0 foot tall, 94 percent of those 1.1 to 1.5 feet tall, and all those over 1.5 feet tall. Comparable values for the pitch pine seedlings were much less: 5 percent of those 0.2 to 0.3 foot tall, 42 percent in the 0.4 to 0.5 foot height class, and 50 to 69 percent in the upper three height classes.

Other observations and data indicate that pitch and shortleaf seedlings have similar sprouting ability when of the same vigor and on the same site.

As a guide in making prescribed burning plans, the following statements seem justified. Probably more than 70 percent of the shade-grown seedlings of either species will sprout after prescribed burns if they are vigorous and have at least well-developed basal crooks, or are more than 3/16 inch in diameter at the root collar. Another alternative criterion, a height of more than 0.5 foot, could often be used; but it is not recommended because of spindly seedlings in some areas.

End Of Basal Sprouting Ability

According to some authors, only young trees of shortleaf pine sprout at the base. Wakeley (7) stated that shortleaf pine sprouts during the first 3 or 4 years of its growth. Mattoon (3) reported that open-grown and vigorous shortleaf pines sprout up to about their eighth year; slow-growing or shaded stems, up to their tenth or twelfth year; and that the upper limit of size at which sprouting may occur ranged from 3 or 4 inches in diameter near the ground for vigorous stems to 2 or 3 inches for trees of slow growth.

However, in southern New Jersey, shortleaf pines may sprout until they are 30 years old. That statement is based on 12 increment cores taken 9 inches above the ground from trees having basal sprouts of known origin (after a fire or cutting) and on sections from 6 other pines. The sprouts started when the trees were 8 to 36 years old, according to

Figure 4.--*Basal sprouts on a pitch pine stump that was at least 70 years old. The stem had been killed by a July wildfire and later was felled for pulpwood.*

age counts. Similar counts on sections taken at the root collars ranged up to 30 years for 5 stems having dormant buds at the base. The other stem apparently had no living dormant buds on the bole, but did have two on an inconspicuous branch that were possibly buried enough in the duff to survive a fire. That stem was 35 years old.

All these original stems had grown in at least partial shade, and none was more than 4 inches in diameter (at a height of 9 inches) when the sprouts started or when living dormant buds at the base were observed.

In contrast, similar borings taken from 10 pitch pines showed that they had sprouted at the base when the trees were 22 to 79 years old (fig. 4).

Five stools of pitch pine from the West Plains section of the New Jersey Pine Region were also examined. Although rot and the two or more generations of sprouts from the same stool made total age counts impossible, the last sprouts had apparently started when the stools were at least 40 to 83 years old.

Bole Sprouts

Borings were taken along the boles just below living dormant buds in 10 pitch pines and 10 shortleaf pines. Age counts of these indicated that the shortleaf pines sampled were 49 to 85 years old at those heights; the pitch pines, 44 to 81 years old.

Of course, many of those buds formed at least the third stage or subdivision of development. For example, a bud developed into a branch that later died, but a bud that had started on that branch persisted for some time, developing into a short shoot or minute stubby branch (fig. 5). And the present bud can be traced back to the latter. Sectioning pitch and shortleaf boles showed that the stage as buds and minute stubby branches can last for 40 to 55 years.

Dormant buds along the bole and main branches form the basis for the recovery of pitch and shortleaf pines from fires that kill, or sometimes consume, the foliage. They and the minute stubby branches are the source of regular branches that develop sometimes on the seed trees left after a heavy cutting.

Effect On Stands

The relative age to which pitch and shortleaf pines still have dormant buds along their boles indicates no appreciable difference between them that would permit fires to modify stand composition. This is revealed, too, by the observed lack of difference in susceptibility to fires that kill appreciable amounts of foliage. In contrast, Virginia and loblolly pines, which do not have similar dormant buds,

are much more susceptible to serious injury or killing by crown scorch.

However, pitch and shortleaf pines do differ greatly in the age to which they will produce basal sprouts. Evidently shortleaf produces them only while relatively young; pitch pine, to an advanced age. This difference, coupled with the difference in seed production, seems a logical basis for explaining the present distribution of these species on upland sites in southern New Jersey.

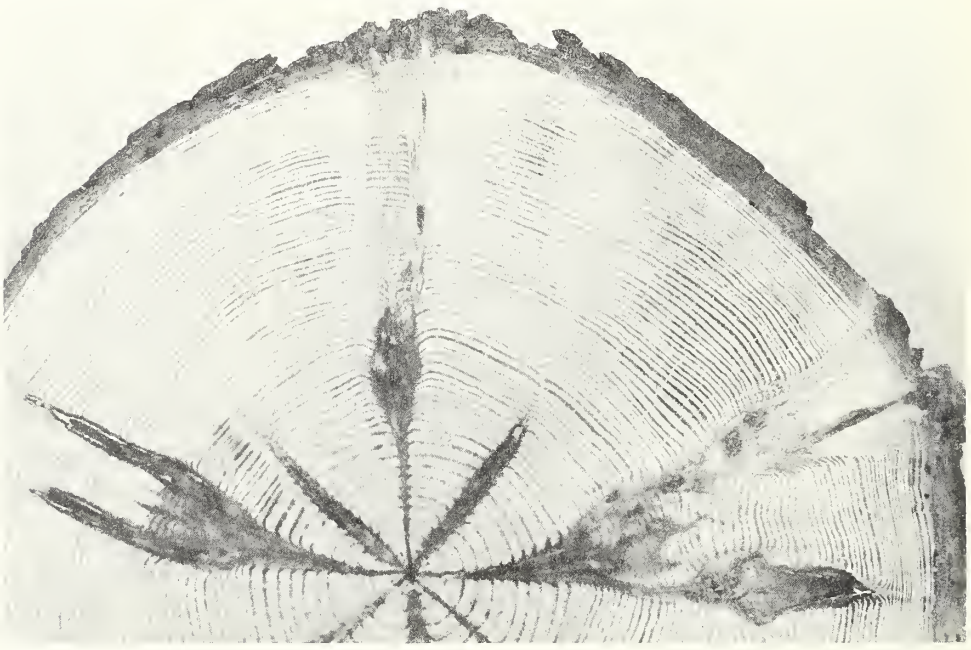

Figure 5.--*Cross section of a shortleaf pine bole showing short shoots and dormant buds that can be traced back to branches that died more than 20 years ago. This section shows 72 annual rings.*

Pitch pine is a much earlier (10 years or so) and more prolific producer of seed, particularly on sprouts, than is shortleaf. Because of its early seed production and its ability to produce sprouts to an advanced age, pitch pine could persist under frequent and severe fires, whereas shortleaf pine might be eliminated within 50 years. Hence, shortleaf pine is absent or very rare in the areas that at one time seem to have had frequent killing wildfires; but it

occurs along with pitch pine in the areas where such fires were less common.

The great age to which pitch pine produces basal sprouts permits also much wider variation in the growth and form of their sprouts than in those of shortleaf. Our observations indicate that with pitch pine:

- Sprouts from seedlings are fully as desirable as seedlings in growth and form.

- Sprouts from saplings can be expected to be somewhat poorer in form; and after an initial period of rapid growth they may have somewhat slower growth than seedling sprouts.

- Sprouts from pole stems or fairly old stools may survive and grow slowly upright, or those from somewhat older stools may have an almost prostrate growth.

- Sprouts from large stems or old stools may start, but soon die.

In contrast, shortleaf sprouts, starting as they do usually from seedlings and saplings, normally have good form and, as Mattoon (3) stated, produce commercial timber.

Pitch pine's ability to sprout to an advanced age is considered primarily responsible for the slow growth of many sprout stands of this species. Part of the trouble with sprouts from an old root system is the large number produced. While a seedling produces few sprouts, old flat stools such as those found in the Plains areas may have as many as 249 living sprouts 1 year old on a single stool. Of course, in areas subjected to less frequent killing fires there are more single stems, and fewer resulting sprouts, than in the Plains areas. But both there and on many of the lowland sites the old age of the stools is a probable reason for the slow growth of present sprout stands of pitch pine.

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